PROCEEDINGS

OF THE

NATIONAL ACADEMY OF SCIENCES

Volume 8 JUNE 15, 1922 Number 6

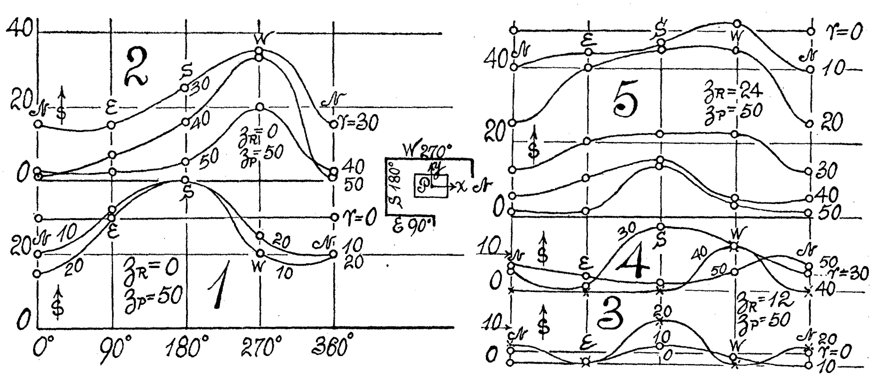
CYLINDRICAL DISTRIBUTION OF NODAL STRENGTH AROUND THE PIPE NORMAL*

By Carl Barus

Department of Physics, Brown University

Communicated, April 14, 1922

1. *Circular and Radial Survey.*—The unexpected non-symmetric results obtained in the last paper, induced me to try a group of experiments relative to the center (nearly) of the table. The resonator was therefore carried in a circle of radius r_R around the plumb line let fall from the mouth of the pipe. The measurements were then repeated for successive levels of the pipe (z_P = 40 cm. and 50 = λ cm. nearly) and of the resonator (z_R = 0, 12 = $\lambda/4$, 24 = $\lambda/2$ cm.). The relation of the different locations is suggested by the inset of figures 1, 2, which is a reduced plan of the room, with the pipe in the vertical above P on the table. The directions $+ y$ (west) and $- x$ (south) are thus toward walls, whereas $+ x$ (north) and $- y$ (east) are largely toward open spaces from the table.



In the first exploration (here omitted) the mouth of the pipe P was z_P = 40 cm. above the table. Carrying the mouth of the resonator on the table with its axis kept parallel to x, around successive circles of radius r_R

= 0, 10, 20, 30, 40, 50 cm. gave intensity distributions, s, very definite and inter-related, but quite unsymmetrical to the pipe vertical. The s-oscillations in eastern and northern R-displacements from the center, (i. e. to open locations) were meager, while the s-oscillations for southern and western directions, trending toward closed parts of the room, were very marked. As r increased from 0 to 10, 20, 30, the maximum intensity lay toward the south; beyond this (r = 40, 50 cm.), it moved to the west. All the maxima of intensity were larger than the intensity on the table, under the pipe ($r = 0$); even at $r = 50$ cm. (meaning a pipe resonator distance of 64 cm.), the s-value was a little in excess of $s = 23$ for the normal case.

Another view of the results was given by collecting all the points on the line S-N along x, and on the line W-E along y. The features of the latter were somewhat vague, but the S-N line presented conspicuous crests and troughs. These were from 40 to 45 cm. apart, and situated on either side of, but without other appreciable reference to the pipe vertical P in their contours. The inference would be that we must look to other causes for their occurrence.

The mouth of the pipe was now raised in the same vertical to $z_P = 50$ cm. above the table, or a little over a wave-length (48 cm.). The data so obtained are constructed in the way described in figures 1, 2, for the rotation of the resonator and figure 6, for its corresponding $\pm x$ and $\pm y$ displacement. The central intensity ($r = 0$) has increased, because of the λ-elevation conformably with the earlier results. The curves as a whole are simpler in outline; the unique maximum is again transferred from S to W as r increases, this time a little sooner, in fact; i.e., before r reaches 30 cm. For large values of r, intermediate azimuths would have been desirable; but as the phenomena are adequately given by the linear surveys of figure 6, the extra labor was thought superfluous. The S-N lines in both surveys are very much alike, the maxima and minima in the case of figure 6 having been shifted into the north or positive x, for the elevated pipe. This also recalls certain earlier results. The distances apart of crests and troughs is here somewhat more difficult to define; but it is still much above 40 cm. and the pipe vertical is ignored as before.

For the fixed position of the pipe, it was now desirable to raise the plane of the resonator and the graphs figures 3, 4, and 5 contain the nodal intensities for an elevation $z_R = 12$ cm. (a quarter wave-length) above the table. This is the level of an antinode at the pipe normal and the curves are therefore low throughout, as in the earlier work for normal positions. Nevertheless as we depart from the pipe normal or center, to circumferences of radii 10, 20, 30 cm., the unique maxima in the south become prominent and beyond $r = 30$, they again shift to the west.

In figure 7, the S-N line has the same characteristics as in figure 6 with

its two marked crests. Somewhat less certainly the resemblance in W-E lines may be detected. As in all the N-S lines the central trough lies for some reason to the right of the pipe normal. The maxima are far apart apparently.

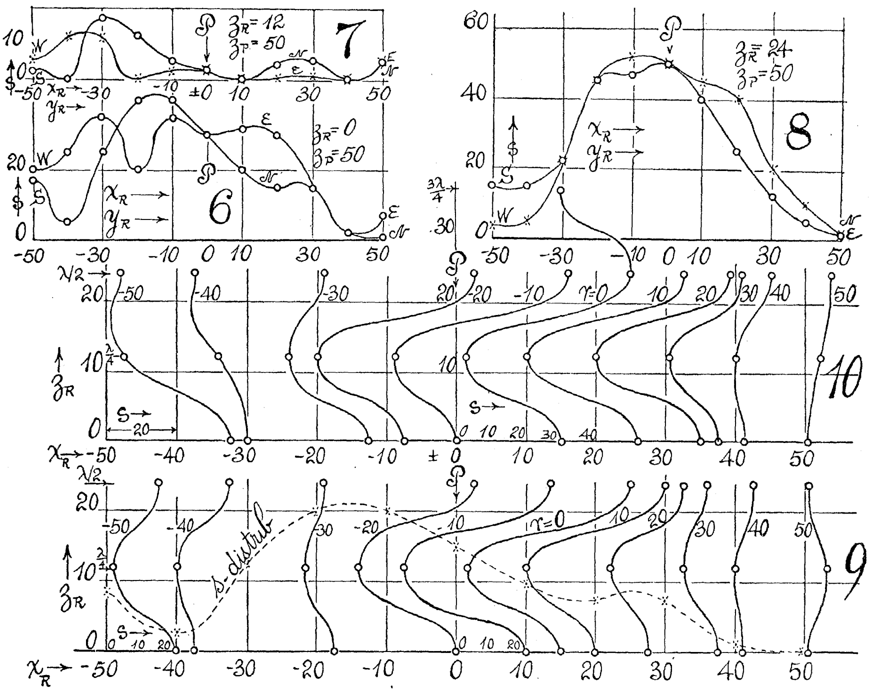
The resonator was finally transfered to a level, $\lambda/2 = 24$ cm. above the table and moved around the pipe axis, its mouth lying on successive circumferences of radii r, with the results given in figure 5. The maxima of all the curves are here curiously flattened; but there is still a gradual transfer of the chief crest from S to W, as r increases. Probably intermediate observations would have modified the curves. Since $\lambda/2$ determines a nodal plane normally below the pipe, the intensities are all relatively large, but they fall off as a whole so rapidly with r, that there is no intersection and all curves may be given in a single diagram.

The graphs showing the intensity, s, along the S-N and W-E directions in figure 8, exhibit a total change of form. The two crests have seemingly all but coalesced near the pipe normal. Owing to an accident which somewhat dislocated the fringes, the indentation in the middle of the S-N curve and the bulge toward the right in the other may need modification but this is of little consequence here, since the plane at a level of $z = 24$; above the table contains a single marked crest, only.

2. *Vertical Survey.*—It is now of interest to bring the values of intensity together when the resonator moves up from the table on the same vertical. As constructed in figure 9, with s laid off horizontally to the right, z_R vertically and with the origin of *each* tripoint s-curve at the x position of the vertical to which it belongs, these vertical distributions of nodal intensity strike the eye. The intensities s on the table for the same x positions are also sketched in. Under the pipe at $z_P = 50$ cm., the nodal surface at the table rapidly decreases in s-intensity to the antinode at $z_R = \lambda/4$; s then rapidly increases again to the more pronounced nodal surface at $z_R = \lambda/2$, nearer the pipe. Toward the south however the distinction between node and antinode is not regularly sustained: at $x = -20$ cm. the antinode has gained in strength and at $x = -30$ cm. the strength of nodes and antinodes does not differ much. Beyond this ($x = -40, -50$), however, nodes and antinodes are again sharply contrasted. Toward the north from the pipe normal ($x = 0$), these differences die out more gradually, until at $x = 50$ cm. the intensities are for some further reason, reversed.

What is very surprising, however, is the observation that throughout the whole of the extent of a linear meter ($x = \pm 50$) symmetrically to the pipe normal, the nodal and antinodal planes at $z_R = 0, \lambda/4, \lambda/2$, remain parallel to the table, so far as can be seen. The only distinction within this stretch is the distribution of nodal intensity as exhibited in the continuous curves sketched in, or separately in figures 6, 7 and 8. It would

therefore here seem to be a mistake to associate wave-length with crests and troughs in these diagrams, however plausibly such inferences may obtrude. It is very much more probable that in the south some extraneous s-distribution has been superposed.



The West-East distributions ($\pm y$) though not so sharp in their features in figures 6, 7 and 8, show an equally pronounced character when treated in the same way relative to vertical variations, in figure 10.

Each of the triplet graphs is to be referred to an origin at the x_R marked on the curve and the s-intervals are 20 scale-parts, as heretofore. Since the edges of the table are at $y = \pm 60$ cm. (nearly), the nodal plane does not extend quite so far; but it does not follow that these edges have much influence on the results, since the same kind of graphs appear in figure 9, where the edges of the table are nearly 50 cm. further. The degradation of the nodal plane occurs first at $y = 50$ cm. in the east as it did in the north.

In the west it is still strong at $y = -40$, and now promises to run through another cycle of intensity as in the previous case. The antinode very nearly $s = 0$ throughout the east, begins to lose identity between $y = -20$ and -30, to be followed by oscillations. Finally, the first nodal plane above the table degenerates here more obviously than before, between $y = -30$ and -40.

The records in figures 9 and 10 contain an almost complete example of a free nodal region sustaining itself $z_R = 24$ cm. above the table, and figure 8 gives the acoustic pressures within it. These are largest near the pipe, though not quite symmetric and it is possible that the direct ray may here influence the resonator. In general, however, i.e., at greater distances, the direct ray is relatively ineffective and it is to the occurrence of nodal regions alone that the resonator then responds, even when the direct ray would seem to have the advantage of nearness. Thus in figure 10, the curve for $r = 0$, when tested at the second antinodal plane ($z_R = 36$ cm.), although the pipe is now but 12 cm. away, nevertheless retains the features of a pronounced minimum.

* Advance note from a Report of the Carnegie Inst., of Washington, D. C.

IONIZATION AND ABSORPTION EFFECTS IN THE ELECTRIC FURNACE

BY ARTHUR S. KING

MOUNT WILSON OBSERVATORY, CARNEGIE INSTITUTION OF WASHINGTON

Communicated April 8, 1922

In 1914, the publication by Fowler of the series formulae for enhanced lines showed that the Rydberg constant "N," occurring in the formulae for arc lines, is changed to 4N for enhanced lines. This established the view based on a very general difference of behavior in both laboratory and celestial sources, that the enhanced lines and the arc lines arise from differently constituted emitting centers. The condition pictured by Bohr's theory is that the enhanced lines are produced by atoms which have lost one electron, while the normal atom emits the arc lines.

Recent work by Saha applies the relations recognized in physical chemistry to the case when the normal atom is changed into an ionized atom with an electron set free. A definite equilibrium is considered as established, represented in the case of calcium by $Ca \rightleftarrows Ca^+ + e$.

It follows from this that if we add a large supply of electrons from some substance which becomes ionized more readily than calcium, fewer electrons from the calcium can exist in the free state, and the proportion of Ca^+ atoms becomes less, with a corresponding weakening of the enhanced lines relative to the lines of the normal atom.

In the electric furnace, the enhanced lines of some substances can be produced faintly, and the effect of a mixture with an easily ionized substance may be tested, under the same conditions of temperature and pressure for the mixture as for the pure substance. Experiments have been